February. Of these Doctor Abbot says (p. 74, second column):

> We have made no use of "long-method" values at Harqua Hala, except for determining "function transmission curves." We consider them individually so much less accurate than "short-method" values, because they are influenced by clearing up or hazing up of the atmosphere, while short-method values are not, that to include them in the mean values would injure the work. The observers at Montezuma have been accustomed to give "long-method" values half weight. We have thought it best not to alter their "weighted mean" values already published in the MONTHLY WEATHER REVIEW, but have modified the grade assigned.

The seeming discredit cast by Doctor Abbot himself upon these long-method results is a surprise to the writer because that method is fundamental and one whose average values must be more accurate and dependable than those by the empirical or short method. The case is somewhat analogous to adopting aneroid barometers for measurements of air pressure to replace fundamental mercurial standards. It is very difficult to properly appraise the real value of the so-called short method which requires for the *evaluation* of its indications a whole train of complicated "function" values of a highly arbitrary and empirical character. The "short-method values" are acceptable only when they follow closely in step with long-method values under good observing conditions.

The writer recognizes that the so-called short method may possibly give truer indications of short-time fluctuations of apparent solar intensity, but it is difficult to believe that in the long run short-method observations can be of superior accuracy to the long method, which must be relied upon for evaluating the long train of complicated "function" values required in the use of the short method. It is again hoped and urged that frequent long-method observations be made and published for each station. It seems highly important also that the observations at the Arizona and Chile stations be made *absolutely independent of each other*, without the application of coordinating corrections that are designed to bring about some imaginary agreement between these two stations. The Weather Bureau fully recognizes that outstanding constant differences may arise, but it seems premature to attempt to evaluate these differences and apply arbitrary corrections to these observations at this early time in the history of the two stations. That is to say, the writer believes the observations should be made as absolutely independent of each other as possible and all outstanding differences harmonized when a large body of observational material is available for dicsussion. Various corrections have been applied to the records in the past which might perhaps better have been left to be determined and evaluated in a final discussion of the material.

Annual period.—Figure 8 of Doctor Abbot's article in this REVIEW for February shows a well-defined 12-month period with maxima values about January. A tendency toward a similar period but opposite in phase can be shown in the Mount Wilson data. Observations at the latter station, however, especially after 1916, extended over such a short portion of the year that a periodic tendency can not be conclusively evaluated.

The logical inference is that any annual period of this character must be due to changes in atmospheric absorption and that the effect of the latter is not as yet completely eliminated. The opposition of phase between Mount Wilson and Chile allows the inference that the feature is a summer and winter influence in the two hemispheres. This, however, is refuted, because seemingly the Harqua Hala and Montezuma annual periods (only a little over one year of record is available) are in the same phase. This raises the question whether the seasonal changes at Montezuma (so-called corrections to constant sun) have not been impressed upon the Harqua Hala results by the empirical corrections required by the short-period method. (See column 2, et seq., p. 73, this REVIEW for February, 1923.)

If the annual period is truly solar, must we not also expect to find other periods corresponding to the inner and outer planets? It seems far better to allow a small apparent error of this kind to remain to be finally evaluated when the body of data is large enough to permit the error to be most assuredly evaluated by rigorous statistical methods.

Placing the highest valuation on long method observations, it is hoped the results of all such for both Harqua Hala and Montezuma may be included in the observations which are submitted for publication in the MONTHLY WEATHER REVIEW from time to time.

WEATHER FORECASTING FROM SHIPS AT SEA.

ALFRED J. HENRY, Meteorologist.

[Weather Bureau, Washington, D. C., May 23, 1923.]

With the development of radio transmission in the early years of the twentieth century, one of the very first practical applications of the new method of transmission was in the issue of warnings of dangerous storms to vessels at sea.

As early as 1906, therefore, arrangements had been made by the United States Weather Bureau to dispatch weather forecasts and warnings to all vessels within the zone of communication that were equipped with radio apparatus.

At that time the idea of a central floating weather station had not developed, but it was thought that perhaps the accuracy of the forecasts might be improved by extending the field of observations from land to water areas, hence arrangements were made whenever possible to transmit ships' observations to shore stations. As it turned out, the extension and development of radio transmission found its fullest expression in eastern United States and northwestern Europe so that vessels navigating the north Atlantic lanes of travel were first to be in a position to communicate with shore stations. For a short time, ships' observations from the north Atlantic were collected by the United States Weather Bureau, but the collection was suspended in the last half of 1907. In the next year, 1908, the outstanding event was the test of the feasibility of the plan of constructing a weather chart on board ships navigating the high seas. This test became possible through the generosity of the Hamburg-American Line in cooperation with Dr. P. Polis, director of the Aachen Meteorological Observatory.[1]

Doctor Polis made the trip, Cherbourg to New York and return, in 1908. The plan followed was to arrange for the transmission of a few reports from European land stations and to supplement these daily by such ships' reports as could be collected. At that time radio transmission from European stations was not effective beyond about 1,800 miles from the British coast; reports from the eastern portion of the United States were

[1] Polis, P.: Wireless telegraphy in the service of meteorology, Mo. WEATHER REV. 36: 407.

then picked up. Although Doctor Polis did not have much material at his disposal a fairly useful map was constructed and the experiment was considered as a success.

The way to an immediate adoption of the plan was not, however, clear; the questions of tolls, codes, and international agreement had first to be disposed of. An International Conference on Radio-Telegraph Transmission was held in Berlin in 1906, a second one in London in 1912, and a third was set for Washington in 1917; for reasons that can easily be recognized the last one was not held, and, moreover, some of the original questions are still under consideration.

In the meantime, it was realized on this side of the Atlantic that the extension of radio transmission of ships' observations made in West Indian waters to the United States Weather Bureau would be productive of useful results; and accordingly, in 1912, a plan of operation whereby meteorological observations were to be made twice daily on ships navigating the Gulf of Mexico, the Caribbean Sea and adjacent waters and transmitted by radio to the United States Weather Bureau was put into effect. The new plan differed from the old in providing for a small compensation for the taking of the observations at stated hours.

In all, about 50 vessels were commissioned to observe twice daily; it was hoped that these reports would be received in the Central Office of the Weather Bureau in Washington in time for use in the preparation of the twice daily forecasts and warnings, a hope that was not always fully realized, although the system proved to be vastly superior to that which was used in the early days of radio transmission.

Prior to 1913, the thought in connection with radio transmission was centered upon the idea of collecting ships' observations for the use of the forecaster at a central land station; in 1913, however, the bureau began to broadcast the meteorological observations taken at a line of coast stations extending from Sydney to Key West.[3] At a later date the original number of land observations broadcast was greatly increased.[3]

The interception of these observations, as well as those made in West Indian waters, of course, made possible the preparation of weather maps and the study thereof immediately on board ship. This was obviously the most effective solution of the problem of keeping the navigator advised as to the meteorological conditions prevailing on the continents and in his immediate vicinity. While this opened up the possibility the problem was only partially solved; what was needed was a forecaster on board the vessel, but the matter received little attention during the actual period of the Great War. Shortly after the war closed the forecasting problem of the Atlantic was actively taken up by the French Weather Bureau (Office National Météorologique) . In a communication from that Bureau under date of April 3, 1922, it was indicated that the object sought could be realized, and in support of this view the experience on board the steamer *Jacques Cartier* was cited, as follows:

On board the *Jacques Cartier* were received the American bulletin and European meteorological messages broadcast by the Eiffel Tower; moreover, passing ships were asked to give meteorological reports for certain hours. Daily forecasts were made on board in accordance with the methods of the National Meteorological Office (study of the movement of variation centers and of cloud systems). These forecasts which gave the best results were broadcast by radio in French and in English to the ships en route. Besides when the *Jacques Cartier* was in touch with European wireless stations, data were forwarded to France.

Thus on the *Jacques Cartier* was realized a first outline of the Atlantic station of centralization forecasting and broadcasting—unfortunately this was a moving station.

In spite of the short range of her wireless station only allowing inquiries at a distance of 150 miles by daytime, the steamship *Jacques Cartier* succeeded in gathering daily an average of five or six observations for a given hour.

The above refers to the conditions found in the period immediately preceding April, 1922. Let us now look at the experience of Captain Coyecque on the *Jacques Cartier* on the voyage, New Orleans to Le Havre, February, 1923. Through the courtesy of the Compagnie Générale Transatlantique, Supervising Forecaster Edward H. Bowie, of the Weather Bureau, was given the opportunity of witnessing at first hand the operation of the system practiced on board the *Jacques Cartier*. Below is a condensed account of the eastward voyage by Captain Coyecque:

VOYAGE OF FEBRUARY, 1923, NEW ORLEANS TO LE HAVRE.

[1. Radiotelegraphic results.]

"During the entire crossing it was possible to materialize with considerable precision the meteorological situation over the United States and most of the ocean, thanks to the regular and exact receipt of messages from Arlington, and of the Annapolis-Lyon telegram, known as "Angot-Paris." The Weather Bureau recently decided to add to the stations included in this radiotelegram the Azores observations. The latter, sent by cable from Horta to New York, are taken at 7 a. m. (message 3.30 p. m.) and at 6 p. m. (message 3.30 a. m.). They are particularly interesting for following in the eastern part of the ocean the indications of falling pressure, their passage on the meridian of the Azores. They make possible the determination of the seat of variations.

"From the 17th of February on, that is, off the Bermudas (65° W.), we received the European meteorological message of 4 a. m. (distance, 3,300 miles). It was possible during the crossing of three-quarters of the Atlantic to materialize the isobaric situation from the Aleutians to Russia; that is to say, about 180° of longitude and 50° of latitude. Thus the charts giving the general situation were traced every day by 1 a. m., Greenwich mean time.

"Mr. E. H. Bowie, Chief Forecaster of the American Weather Bureau, who had taken passage on board for this crossing, was very much surprised at this result, which is, to be sure, surprising on first view. We believe we may add that this was the first time that it was possible to realize on board a ship crossing the Atlantic such an exact knowledge of the situation of the weather on the larger part of the Northern Hemisphere at an average of 10 hours after the observations.

"The Arlington day message was received up to the 26th of February (longitude 20° W., distance, 2,500 miles); the night message up to the 1st of March (Ushant, 3,000 miles), with the exception of the break on the 28th of February. These results are analogous to those of our voyage out. The atmosphere became very stormy from the 25th of February, making the reading of long-distance messages very difficult.

"The European meteorological message of 10 a. m. was received and used from the 21st of February on; i. e., at longitude 48° W. (2,500 miles). That of 1 p. m. was used some days after, thus making possible by its combination with the Arlington message the tracing of a chart of synoptic observations for Europe, the Atlantic, and the eastern half of the United States.

Receipt and retransmission of observations made on ships.—"Our return trip was characterized by the receipt of a very great number of ships' observations.

[3] Professor McAdie informs me that weather reports from Tatoosh to San Diego on the Pacific coast were broadcast from San Francisco in 1906 or early in 1907.—EDITOR.
[3] cf. Calvert, E. B.: MO. WEATHER REV. 51 : 1-9.

"In the West Atlantic, and particularly between the Bermudas and the Azores, it was possible to trace all the charts with precision, thanks to the complementary information which we received. The mean number of observations received daily was more than 10. For some days, which coincided with the passing of a very strong tempest in the North Atlantic, we received an average of 20 simultaneous observations from ships. The record was reached on the 22d of Feburary at 1 p. m., with 30 simultaneous observations.

"In the East Atlantic, where the radio traffic is very intense, as usual, we received only one rather feeble mean of observations of ships, but thanks to the message received from the Eiffel Tower, and to our communications with the steamers of the line from New York, the tracing of the charts was not less precise. We retransmitted to the Office National Météorologique the observations of the steamship *France;* those of the *Lafayette*, bound to the southwest of Spain toward the Azores, and finally those of the steamship *Paris*, bound for New York. As soon as this ship lost direct contact with Brest, we took charge of the retransmission of the messages. Two appointments were made a day for this purpose, and the observations of the *Paris* were retransmitted to the Office National Météorologique with ours immediately afterwards.

"The Weather Bureau is disposed to maintain this service of retransmission by the "Angot" message; it wishes only when the *Jacques Cartier* is on the sea, to receive our observations, too. These will be added by the Office National Météorologique to the European messages of "Lyon-Annapolis." We are favorable to this idea, which would make the *Jacques Cartier* play a true rôle of "meteorological cruiser" and centralization station. There would also be a chance to authorize us to transmit clearly the positions of the centers of depression. information which would be exchanged between the two meteorological services via Annapolis-Lyon.

CONCLUSION.

"We believe we can affirm that from the point of view of receipt, as well as of transmissions and retransmissions, we have obtained in the course of the voyage of January and February, 1923, results which are incomparably superior to all preceding ones. Mr. Bowie showed great astonishment at the results obtained. He declared to us that he had never had an idea of the precision with which one could follow the evolution of meteorological phenomena and forecast their effects, while crossing the ocean. We believe that from the moment the United States has verified this success officially, the Office National Météorologique will leave no stone unturned to keep up the present organization of the *Jacques Cartier*, which on this voyage exceeded all hopes. We will close by citing the number of meteorological messages which were received by the two operators of the *Jacques Cartier*, and the number of telegrams of information, general or particular, which were sent. The first number is 500 messages received; the second, 140 messages sent. Finally, we will remark that the results obtained are largely due to the regularity of the radio service and the precision with which the messages are received. The two radiotelegraphers are at present giving us incomparable service, and the training of other operators for this work would seriously upset the enterprises by dissipating our energy for an undetermined period of time. We are therefore of the opinion that it is indispensable to grant to these officers a special indemnity in keeping with the services which they render to the Office National Météorologique and to Atlantic meteorology."

The single example of the weather information broadcast by the *Jacques Cartier* here given will convey an excellent idea of the scope of the meteorological activities of that vessel:

BROADCAST—MARCH 20TH—GREENWICH NOON.

Meteo. *Jacques Cartier* to all ships: North Atlantic weather situaiion March 20th, Greenwich noon.—Pressure is high over northwestern Europe 30.36; also from Bermuda to Azores and northward also over American Atlantic States. Trough of low pressure extending from Iceland (29.60) southeastward to Gibralter (29.50). Disturbance of great intensity (29.00) over Newfoundland moving east-northeastward.

Forecasts.—Track, Azores to Gibralter—unsettled weather eastern portion—northerly fresh winds, squally weather and overcast weather western portion. Stop. Tracks, Azores to English Channel—overcast weather and moderate easterly winds eastern portion—fresh or strong northerly winds and squally weather western portion. Stop Azores region—fresh northerly winds moderating to-day and shifting to southeast and south to-morrow—overcast weather becoming fair. Track. Azores to Bermuda—Moderating northerly winds and fair weather between longitudes 30° and 42°. Southerly increasing winds shifting to southwest west of 42; weather becoming overcast and probably rainy.

Advisory for westbound ships over transatlantic tracks west of Ireland to south of Grand Banks: Disturbance of great intensity (29.00) over Newfoundland moving toward Iceland will be attended by strong shifting winds to-day and to-night between longitudes 35° & 55° followed by fresh or strong northerly winds. Winds will shift to-morrow morning between 40° & 50°.

CONCERNING THE ACCURACY OF FREE-AIR PRESSURE MAPS.[1]

By C. LE ROY MEISINGER, Meteorologist.

[Weather Bureau, Washington, D. C., April 1, 1923.]

INTRODUCTION.

The necessity for knowing the accuracy of the charts.—The computation of barometric pressure at free-air levels is a purely mechanical operation after one has constructed the necessary tables; but the verification of the results of such computations is a much more difficult matter, since a rigidly accurate standard of comparison does not exist. It is true that free-air pressures and temperatures are measured by means of kites, and wind velocities by pilot balloons, but these measures are, for one reason or another, frequently not comparable with the results of computation.

Experience has demonstrated that maps depicting the barometric distributions at free-air levels are often considerably at variance with those representing sea-level conditions. If these differences are real, it is reasonable to suppose that they are physically significant, and one may hope to learn by study and experience what the significance is. On the other hand, if they are false, one may be seriously misled in attempting to interpret them. Therefore, if we are to have confidence in these charts, it is imperative that we ascertain, in every possible way, the degree of accuracy that may be expected of them. This is the purpose of the present inquiry.

The maps upon which the inquiry is based.—The maps examined in the preparation of this paper were constructed daily during the months of December, 1922, and January and February, 1923, from postcard reports mailed to the Central Office of the Weather Bureau at Washington, from 29 Weather Bureau stations in the central and eastern United States. Under the authority

[1] Presented before the American Meteorological Society, at Washington, D. C., Apr. 16, 1923.